

FORM PTO-1390  
(REV. 12-2001)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371

WATK-227

U.S. APPLICATION NO. (If known, see 37 CFR 1.5

10/049421

INTERNATIONAL APPLICATION NO.

PCT/JP00/05600

INTERNATIONAL FILING DATE

22 August 2000

PRIORITY DATE CLAIMED

31 Aug 1999 28 Apr 2000  
1 Mar 2000TITLE OF INVENTION NON-Cu-BASED CAST Al ALLOY AND METHOD  
FOR HEAT TREATMENT THEREOF

APPLICANT(S) FOR DO/EO/US Takayuki SAKAI, Ogasa-gun, Japan.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
  - b. ☒ has been communicated by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
  - a. ☒ is attached hereto.
  - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
  - b. ☐ have been communicated by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

## Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
14. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:
  - International Publication Application Cover Page;
  - Application Data Sheet;
  - PCT Request; and
  - The executed Declaration & Assignment with fees will follow.

PLEASE ACCEPT THIS AS  
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DEP. ACCT. 16-0331  
PARKHURST & WENDEL

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|---|--|---|--|--|--|
| 10/049421<br>US APPLICATION NO. (37 CFR 1.53) |  | INTERNATIONAL APPLICATION NO.<br>PCT/JP00/05600 |  | ATTORNEY'S DOCKET NUMBER<br><b>WATK: 227</b> |  |
|---|--|---|--|--|--|

|  |              |              |                  |                                  |        |
|--|--------------|--------------|------------------|----------------------------------|--------|
| 21. <input checked="" type="checkbox"/> The following fees are submitted:<br><b>BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):</b><br>Neither international preliminary examination fee (37 CFR 1.482)<br>nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO<br>and International Search Report not prepared by the EPO or JPO. .... <b>\$1040.00</b><br>International preliminary examination fee (37 CFR 1.482) not paid to<br>USPTO but International Search Report prepared by the EPO or JPO ..... <b>\$890.00</b><br>International preliminary examination fee (37 CFR 1.482) not paid to USPTO<br>but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... <b>\$740.00</b><br>International preliminary examination fee (37 CFR 1.482) paid to USPTO<br>but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... <b>\$710.00</b><br>International preliminary examination fee (37 CFR 1.482) paid to USPTO<br>and all claims satisfied provisions of PCT Article 33(1)-(4) ..... <b>\$100.00</b><br><b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b> |              |              |                  | <b>CALCULATIONS PTO USE ONLY</b> |        |
|  |              |              |                  | \$                               | 890.00 |
| Surcharge of <b>\$130.00</b> for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30<br>months from the earliest claimed priority date (37 CFR 1.492(e)).  |              |              |                  | \$                               |        |
| CLAIMS   | NUMBER FILED | NUMBER EXTRA | RATE             | \$                               |        |
| Total claims   | 9 - 20 =     | 0            | x <b>\$18.00</b> | \$                               |        |
| Independent claims   | 3 - 3 =      | 0            | x <b>\$84.00</b> | \$                               |        |
| MULTIPLE DEPENDENT CLAIM(S) (if applicable)  |              |              |                  | \$                               |        |
|  |              |              |                  | \$                               |        |
| <b>TOTAL OF ABOVE CALCULATIONS =</b>   |              |              |                  | \$                               | 890.00 |
| <input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above<br>are reduced by 1/2.  |              |              |                  | \$                               |        |
| <b>SUBTOTAL =</b>  |              |              |                  | \$                               | 890.00 |
| Processing fee of <b>\$130.00</b> for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30<br>months from the earliest claimed priority date (37 CFR 1.492(f)).   |              |              |                  | \$                               |        |
| <b>TOTAL NATIONAL FEE =</b>  |              |              |                  | \$                               | 890.00 |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be<br>accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property +   |              |              |                  | \$                               |        |
| <b>TOTAL FEES ENCLOSED =</b>   |              |              |                  | \$                               | 890.00 |
|  |              |              |                  | Amount to be<br>refunded:        | \$     |
|  |              |              |                  | charged:                         | \$     |

a. ☒ A check in the amount of \$ 890.00 to cover the above fees is enclosed. CK# 15035

b. ☐ Please charge my Deposit Account No. \_\_\_\_\_ in the amount of \$ \_\_\_\_\_ to cover the above fees.  
 A duplicate copy of this sheet is enclosed.


c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any  
 overpayment to Deposit Account No. 160331. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card  
 information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR  
 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

|  |   |
|--|---|
| SEND ALL CORRESPONDENCE TO:<br>Roger W. Parkhurst<br>PARKHURST & WENDEL, L.L.P.<br>1421 Prince St., Ste. 210<br>Alexandria, VA 22314-2805<br>Tel: (703) 739-0220 | <div style="text-align: center;"> <br/>         SIGNATURE       </div> <div style="text-align: center;"> <u>Roger W. Parkhurst</u><br/>         NAME       </div> <div style="text-align: center;"> <u>25,177</u><br/>         REGISTRATION NUMBER       </div> |
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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

Takayuki SAKAI

Serial No.: New Application

Filed: February 12, 2002

For: NON-Cu-BASED CAST Al ALLOY AND METHOD  
FOR HEAT TREATMENT THEREOFPRELIMINARY AMENDMENTCommissioner for Patents  
Washington, D.C. 20231

Sir:

Prior to examination of the above-identified application,  
please enter the following specification changes as noted below:

IN THE CLAIMS:

Please amend claims 4, 5 and 9 as follows:

4. (Amended) The non-Cu-based cast Al alloy according to  
claim 1, wherein said non-Cu-based cast Al alloy is a  
precipitation hardened alloy.

5. (Amended) The non-Cu-based cast Al alloy according to claim 1, wherein said non-Cu-based cast Al alloy is used for vehicle wheels.

9. (Amended) The method of heat treatment according to claim 7, wherein said fluidized bed is formed by the direct blowing of hot air.

REMARKS

Claims 1-9 remain herein. Claims 4, 5 and 9 have been amended hereby.

This Preliminary Amendment is submitted to eliminate multiply dependent claims from the above-identified application.

Examination of this application on its merits is respectfully requested.

Respectfully submitted,

PARKHURST & WENDEL, L.L.P.

February 12, 2002

Date



Roger W. Parkhurst

Registration No. 25,177

Attachment:

Mark Up of Amended Claims

RWP/ame

Attorney Docket No. WATK:227

PARKHURST & WENDEL, L.L.P.  
1421 Prince Street, Suite 210  
Alexandria, Virginia 22314-2805  
Telephone: (703) 739-0220

## CLAIMS

1. A non-Cu-based cast Al alloy that contains substantially no Cu, wherein

the tensile strength thereof is 305 MPa or more, the 0.2% yield strength thereof is 220 MPa or more, and the elongation thereof is 10% or more.

2. The non-Cu-based cast Al alloy according to claim 1, containing 6.5 to 7.5% Si by mass, and 0.36% or less Mg by mass.

3. The non-Cu-based cast Al alloy according to claim 2, wherein said non-Cu-based cast Al alloy contains 20 to 70 ppm of Sr.

4. The non-Cu-based cast Al alloy according to ~~any of claims 1 to 3~~ claim 1, wherein said non-Cu-based cast Al alloy is a precipitation hardened alloy.

5. The non-Cu-based cast Al alloy according to ~~any of claims 1 to 4~~ claim 1, wherein said non-Cu-based cast Al alloy is used for vehicle wheels.

6. A method for heat treatment of a cast Al alloy comprising; subjecting a work piece of the cast Al alloy to solution treatment, and then

subjecting the work piece to aging treatment, to improve mechanical properties of the work piece, wherein at least said solution treatment is performed by rapidly raising the temperature to the solution treatment temperature within 30 minutes, and maintaining said solution treatment temperature within 3 hours to form the non-Cu-based cast Al alloy that has a tensile strength of 305 MPa or more, a 0.2% yield strength of 220 MPa or more, and an elongation of 10% or more.

7. A method for heat treatment of a cast Al alloy comprising; subjecting a work piece of the cast Al alloy to solution treatment, and then

subjecting the work piece to aging treatment, to improve mechanical properties of the work piece,

wherein at least said solution treatment is performed by allowing said work piece to be present in a fluidized bed to form the non-Cu-based cast Al alloy that has a tensile strength of 305 MPa or more, a 0.2% yield strength of 220 MPa or more, and an elongation of 10% or more.

8. The method of heat treatment according to claim 7, wherein said aging treatment is performed by allowing said work piece to be present in a fluidized bed.

9. The method of heat treatment according to claim 7 or 8, wherein said fluidized bed is formed by the direct blowing of hot air.

DESCRIPTION

Non-Cu-Based Cast Al Alloy and Method for Heat Treatment  
Thereof

Technical Field

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The present invention relates to a non-Cu-based cast Al alloy that contains substantially no Cu, and to a method for the heat treatment thereof.

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Background Art

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Al-Si-based aluminum (Al) alloys that mainly consist of Al containing several percent Si by weight have been known as Al alloys for casting or die casting, and multi-phase Al-Si-based alloys that further contain other elements such as Cu and Mg in addition to the basic composition of the Al-Si-based Al alloys have been used as alloys for casting. This is because these alloys have better properties important for casting or die casting, such as the fluidity of the molten metal and mold filling, than other alloys; little casting crack occurs; alloys that have higher strength can be obtained by combining other elements; and these alloys have a small coefficient of thermal expansion and a high wear resistance.

20



Examples of Al-Si-based alloys to which a small quantity of Mg is added include AC4A, AC4C, and AC4CH. These alloys have increased strength by the effect of heat treatment to precipitate the intermediate phase of  $Mg_2Si$ . In particular, AC4C and AC4CH, which has increased toughness by limiting the Fe content to 0.20% by mass or less, is used as alloys for wheels of vehicles such as motor vehicles.

Furthermore, Al-Si-based alloys to which small quantities of Mg and Cu are added are also used. The strength of these alloys is improved by precipitation hardening by the intermediate phase of  $Mg_2Si$ , solid solution hardening by Cu, and precipitation hardening by the intermediate phase of  $Al_2Cu$ .

As described above, the improvement of strength of heat-treated Al alloys is achieved by the addition of other elements, and the aging and precipitation of resultant intermediate phases, and the heat treatment for aging and precipitation consists of the solution treatment and the aging treatment. The solution treatment is a heat treatment for obtaining the solid solution of a uniform composition at a high temperature, by adding a non-equilibrium phase crystallized during solidification to form a solid solution, and further adding a precipitated phase during cooling to form the solid solution. The aging treatment carried out following the solution treatment is a heat treatment for making the precipitated intermediate phases fine and uniform, and for causing precipitation hardening with the

precipitated intermediate phases. These heat treatments improve the mechanical properties of the Al alloy.

Heretofore, although a controlled atmosphere furnace that uses the air as the heat medium, such as a tunnel furnace, has been used for the solution treatment and the aging treatment of such Al alloys, heating-up takes a long time, and the deviation of temperature is as large as about  $\pm 5^{\circ}\text{C}$ , resulting in the difficulty of the solution treatment at a higher temperature.

Although above-described Al-Si-based alloys to which various elements such as Mg and Cu are added have been used as the Al alloys as the mechanical properties, they have a tensile strength of about 290 MPa, a 0.2% yield strength of about 200 MPa, and an elongation of about 8%. In an Al alloy used for wheels of motor vehicles, it is advantageous to improve the mechanical properties such as tensile strength, 0.2% yield strength, and elongation, to make the wheels of motor vehicles thinner, thereby reducing the entire weight of the motor vehicle, decreasing rolling resistance, and contributing to the elevation of fuel consumption and exhaust gas purification performance, as well as the improvement of driving stability.

On the other hand, although the strength of an Al alloy has been improved by adding Cu to the Al alloy, as described above, the corrosion resistance of the Al alloy lowers if more than a predetermined quantity of Cu is added.

Considering the above-described problems in conventional Al alloys, an object of the present invention is to provide a non-Cu-based cast Al alloy that has well-balanced mechanical properties of tensile strength, yield strength, and elongation.

Another object of the present invention is to provide a method for the heat treatment of a non-Cu-based cast Al alloy that can perform the solution treatment at an increased speed of heating-up time, with small deviation of temperature, and at a higher temperature.

#### Disclosure of Invention

According to the present invention, there is provided a non-Cu-based cast Al alloy that contains substantially no Cu, wherein the tensile strength thereof is 305 MPa or more, the yield strength thereof is 220 MPa or more, and the elongation thereof is 10% or more.

Also, the Al alloy of the present invention preferably contains 6.5 to 7.5% by mass of Si, and 0.36% by mass or less Mg, and more preferably contains 20 to 70 ppm of Sr. It is also preferable that the Al alloy of the present invention is a precipitation hardened alloy. Such a non-Cu-based cast Al alloy can be suited to wheels of vehicles such as motor vehicles.

Also, according to the present invention, there is provided a method for heat treatment of a cast Al alloy

comprising; subjecting a work piece of the cast Al alloy to solution treatment, and then subjecting the work piece to aging treatment, to improve mechanical properties of the work piece, wherein at least said solution treatment is performed by rapidly raising the temperature to the solution treatment temperature within 30 minutes, and maintaining said solution treatment temperature within 3 hours to form the non-Cu-based cast Al alloy that has a tensile strength of 305 MPa or more, a 0.2% yield strength of 220 MPa or more, and an elongation of 10% or more.

Furthermore, according to the present invention, there is provided a method for heat treatment of a cast Al alloy comprising; subjecting a work piece of the cast Al alloy to solution treatment, and then subjecting the work piece to aging treatment, to improve mechanical properties of the work piece, wherein at least said solution treatment is performed by allowing said work piece to be present in a fluidized bed to form the non-Cu-based cast Al alloy that has a tensile strength of 305 MPa or more, a 0.2% yield strength of 220 MPa or more, and an elongation of 10% or more.

In the heat treatment method of the present invention, the above-described aging treatment is preferably performed by allowing the work piece to be present in a fluidized bed. Also, the fluidized bed is preferably formed by the direct blowing of hot air.

Brief Description of Drawings

Fig. 1 is a schematic diagram showing an example of hot air direct blowing fluidized beds used in the present invention.

Fig. 2 is a schematic diagram showing an example of fluidized bed type solution treatment furnace used in the present invention.

Fig. 3 is a plan showing an example of aluminum wheels for vehicles.

Fig. 4 is a graph showing the heat treatment schedule in the Example.

Fig. 5 is a graph showing the results of tensile tests for Example and Comparative Example.

Fig. 6 is a graph showing the results of impact and hardness tests for Example and Comparative Example.

Fig. 7 is a graph showing the heat treatment schedule in the Comparative Example.

#### Best Mode for Carrying Out the Invention

The present invention will be described below in detail.

A cast Al alloy of the present invention is a non-Cu-based cast Al alloy that contains substantially no Cu, and has mechanical properties, such as tensile strength, 0.2% yield strength, and elongation, of predetermined values or more, specifically, a tensile strength of 305 MPa or more,

a 0.2% yield strength of 220 MPa or more, and an elongation of 10% or more.

Here, "contains substantially no Cu," means that the content of Cu in the Al alloy is 0.1% by mass or less. When the content of Cu in the Al alloy is 0.1% by mass or less, the Cu has no effect of improving strength, and does not lower the corrosion resistance of the Al alloy. The present invention relates to such a non-Cu-based cast Al alloy.

The non-Cu-based cast Al alloy according to the present invention has a tensile strength of 295 MPa or more, preferably 305 MPa or more, most preferably 320 MPa or more; a 0.2% yield strength of 220 MPa or more, preferably 240 MPa or more, most preferably 260 MPa or more; and an elongation of 10% or more, preferably 12% or more, most preferably 14% or more.

Here, the mechanical properties, such as the tensile strength, 0.2% yield strength, and elongation, of the Al alloy were measured in accordance with the test methods specified in JIS (Japanese Industrial Standards) Z2201.

The non-Cu-based cast Al alloy of the present invention that has the specified or better mechanical properties has the Al-based composition that preferably contains 6.5 to 7.5% Si by mass and 0.36% by mass or less Mg, and more preferably 20 to 70 ppm of Sr. That is, the Si content within a range between 6.5 and 7.5% by mass is preferable because the casting properties of the Al alloy are improved in this range, and a range between 6.8 and 7.2% by mass is further preferable.

The casting properties of the Al alloy are worse when the Si content beyond the range between 6.5 and 7.5% by mass.

It is preferable that the content of Mg is 0.36% by mass or less. On the heat treatment, Mg precipitates an intermediate phase known as the  $Mg_2Si$  phase together with Si, thereby causing significant aging hardening to occur. However, although the content of Mg exceeding 0.36% by mass increases tensile strength or the like, the problem of decrease in elongation arises.

Also, Sr acts as an agent for reducing the size of eutectic structures of the Al alloy, and the content of Sr is preferably 20 to 70 ppm, more preferably in a range between 30 and 60 ppm.

It is preferable that the non-Cu-based cast Al alloy of the present invention is a precipitation-hardened alloy in which an intermediate phase such as  $Mg_2Si$  phase is precipitated by heat treatment as described above. Also, since the non-Cu-based cast Al alloy of the present invention has predetermined or better mechanical properties, such as tensile strength, 0.2% yield strength, and elongation, and these three properties are well balanced, it can be used very effectively for the wheels of vehicles such as motor vehicles.

JIS specifies that AC4C Al alloy contains 0.25% by mass or less Cu and 0.55% by mass or less Fe; and AC4CH Al alloy contains 0.2% by mass or less Cu and 0.2% by mass or less Fe. These Al alloys are effective as long as the above-

described compositions of the present invention are satisfied.

Next, the non-Cu-based cast Al alloy of the present invention that has the above-described mechanical properties and compositions can be manufactured by the method for the heat treatment described below.

First, after a casting of the Al alloy (work piece) made using an ordinary method is subjected to the solution treatment, the casting is generally quenched, and then subjected to the aging treatment. By subjecting the casting to these treatments, the mechanical properties of the Al alloy can be improved so as to apply to desired uses such as vehicle wheels.

In the solution treatment of the present invention, it is important to raise the temperature of the work piece quickly to the temperature of the solution treatment in a short period of time within 30 minutes, and maintain the work piece at this temperature for 3 hours or less. More specifically, it is preferable to heat the Al alloy to the solution treatment temperature of 530 to 550°C in about 3 to 30 minutes, and maintain the solution treatment temperature of 530 to 550°C for 3 hours or less, preferably 1 hour or less in order to prevent the formation of spherical and coarse eutectic structure. As a result, the strength and elongation properties of the resultant Al alloy are improved.

In the solution treatment of the present invention, as described above, it is important to heat the work piece in



a short period of time. For example, in the case of vehicle wheels, it is preferable to raise the temperature to 530 to 550°C in 3 to 10 minutes. This is especially preferable for preventing the formation of coarse eutectic structure.

5 In the solution treatment of the present invention, it is sufficient to heat the work piece quickly, and the method is not limited to a specific method. That is, quick heating of the work piece can be achieved by controlling the ambient temperature, and for example, high-frequency heating,  
10 low-frequency heating, or far-infrared heating can be utilized, but quick heating using a fluidized bed is more preferable.

Quick heating using a fluidized bed is performed by placing the work piece in a fluidized bed.

15 The fluidized bed is formed by granular substances such as powder and granules heated and evenly mixed by hot air, and has features of making the temperature in the fluidized bed substantially uniform, as well as a high thermal conductivity.

20 The present invention utilizes these features of the fluidized bed in the solution treatment of the work piece. The temperature uniformity (about  $\pm 2$  to  $3^{\circ}\text{C}$ ) in the fluidized bed enables the solution treatment to be carried out at a higher temperature, and the high thermal conductivity  
25 shortens time for heating to the solution treatment temperature. These features are great advantage over

conventional controlled atmosphere furnace using the air as the heat medium.

After the work piece is subjected to the solution treatment, it is quenched to room temperature, and is  
5 subjected to the aging treatment. This aging treatment is not limited to a specific method, and a conventional controlled atmosphere furnace using the air as the heat medium (tunnel furnace) can be used; however, the use of a fluidized bed is preferable as in the solution treatment.  
10 This is because the time for the aging treatment can be shortened, and when a fluidized bed is used for the solution treatment, the use of the same fluidized bed is preferable from the points of view of control and operation of the whole process.

15 Also although indirect heating systems, such as the vessel heating system to heat the vessel of the fluidized bed from the outside as a fluidized bed system, and the radiant tube system that incorporates radiant tubes in the fluidized bed, have been known and can be used, the formation of the  
20 fluidized bed using a direct heating system by directly blowing hot air is preferable because the better temperature distribution in the fluidized bed can be achieved.

Next, conditions for the method of the heat treatments in the present invention will be described.

25 First, the solution treatment of the work piece is carried out by heating the work piece to 530 to 550°C in about 5 to 30 minutes, and maintaining the temperature for several

minutes to 3 hours, preferably several minutes to 1 hour. The temperature for the solution treatment is more preferably 540 to 550°C, and most preferably 545 to 550°C. The work piece is then quenched to room temperature.

5        Next, the work piece is subjected to the aging treatment. The aging treatment is preferably carried out by heating the work piece to 160 to 200°C in several minutes, and maintaining the temperature for several ten minutes to several hours. The temperature for the aging treatment is more preferably  
10       170 to 190°C.

Next, the method for the heat treatment of the present invention will be described in further detail referring to drawings.

Fig. 1 is a schematic diagram showing an example of  
15       direct blowing hot air fluidized beds used in the present invention. In a vessel 10, granular substances such as powder and granules 12 are packed on a perforated plate 16, and these granules 12 are fluidized and evenly mixed by hot air 14 blown from the bottom of a perforated plate 16 to form  
20       a fluidized bed 18.

Fig. 2 is a schematic diagram showing an example of fluidized bed type solution treatment furnace used in the present invention. In Fig. 2, the numeral 20 represents a hot air generator, in which the air sent by a blower (not  
25       shown) is heated by flames from a burner 22 to form hot air of a temperature of 700 to 800°C. This hot air is blown to a fluidized bed type solution treatment furnace 26 through

a hot air temperature monitor 24. In the fluidized bed type solution treatment furnace 26, the hot air is blown from a perforated pipe 28 into the fluidized bed 30 to fluidize and heat the granules 32. Thus, the fluidized bed 30 is heated to 530 to 550°C, and the uniformity of temperature in the furnace, in which the deviation of the furnace temperature is about 6°C ( $\pm 3^\circ\text{C}$ ), and the deviation at a point is about 3°C, can be achieved. The work piece 34 present in the fluidized bed 30 is rapidly heated. A granules discharging valve 36 is used for adequately discharging the granules 32.

Although it is not shown, the fluidized bed as shown in Figs. 1 and 2 can be used in the aging treatment of the present invention.

The present invention will now be described referring to examples.

(Example)

The heat treatments of the present invention were carried out using a fluidized bed type solution treatment furnace shown in Fig. 2, and a fluidized bed type heat treatment furnace of a like constitution as an aging treatment furnace.

The fluidized bed type solution treatment furnace is constituted of a cylindrical fluidized bed vessel of an inner diameter of 1500 mm, with a straight part of a height of 750 mm, and an inverse conical bottom part. The aging treatment furnace has also the same constitution as the solution

treatment furnace. As the granules, sand of an average particle diameter of 50 to 500  $\mu\text{m}$  was used.

A cast aluminum vehicle wheel (20 kg) was heat-treated, and test pieces were cut from the outer rim flange and the spoke. The above-described aluminum wheel contained 7.0% Si by mass, 0.34% Mg by mass, 50 ppm of Sr, the balance being Al.

As heat treatment conditions, the solution treatment temperature was 550°C, the aging treatment temperature was 190°C, the heating-up time to the solution treatment temperature was 7 minutes, and the time to maintain the solution treatment temperature was 53 minutes, and the heat treatments were carried out in the schedule shown in Fig. 4.

Test pieces ( $n = 4$ ) were cut from the heat-treated aluminum vehicle wheel, and were subjected to the tensile test (tensile strength, 0.2% yield strength, and elongation), the impact test, and the hardness test. The results are shown in Figs. 5 and 6.

#### (Comparative Example)

A cast aluminum vehicle wheel was heat-treated using a conventional tunnel furnace (controlled atmosphere furnace) for solution treatment and aging treatment, under the conditions of a solution treatment temperature of 540°C, an aging treatment temperature of 155°C, a heating-up time to the solution treatment temperature of 1 hour 12 minutes, and a time to maintain the solution treatment temperature

was 4 hours, and the heat treatments were carried out in the schedule shown in Fig. 7. Other conditions were the same as in the Example.

Test pieces ( $n = 4$ ) were cut from the heat-treated aluminum vehicle wheel, and were subjected to the tensile test (tensile strength, 0.2% yield strength, and elongation), the impact test, and the hardness test. The results are shown in Figs. 5 and 6.

As the above-described impact test, the impact strength was measured using the Charpy impact testing method specified in JIS. As the hardness test, the Rockwell hardness was measured using the testing method specified in JIS Z2245. (Discussion)

As the results of the tensile tests, impact tests, and hardness tests of the Example and Comparative Example obviously show, the aluminum vehicle wheel obtained from the Example has a tensile strength of 334 MPa or more, a 0.2% yield strength of 262 MPa or more, and an elongation of 12% or more. All of these values satisfied the required values of the tensile test, and in particular, the tensile strength was significantly improved compared with the tensile strength of conventional products.

What was specially noted was that by the use of a fluidized bed type furnace adopted in the Example for both solution treatment and aging treatment, the total time required for the heat treatments were shortened as

significantly as about 70% decrease compared with the use of a conventional tunnel furnace.

#### Industrial Applicability

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According to the heat treatment method of the present invention, as described above, the solution treatment can be performed by quick heating-up, with small deviation of temperature, and at a higher temperature, the total time for heat treatments can be shortened significantly compared with conventional methods.

15

Also according to the present invention, there is provided a non-Cu-based cast Al alloy that has well-balanced three mechanical properties of tensile strength, yield strength, and elongation.

## CLAIMS

1. A non-Cu-based cast Al alloy that contains substantially no Cu, wherein

the tensile strength thereof is 305 MPa or more, the  
5 0.2% yield strength thereof is 220 MPa or more, and the elongation thereof is 10% or more.

2. The non-Cu-based cast Al alloy according to claim 1, containing 6.5 to 7.5% Si by mass, and 0.36% or less Mg by mass.

10 3. The non-Cu-based cast Al alloy according to claim 2, wherein said non-Cu-based cast Al alloy contains 20 to 70 ppm of Sr.

15 4. The non-Cu-based cast Al alloy according to any of claims 1 to 3, wherein said non-Cu-based cast Al alloy is a precipitation hardened alloy.

5. The non-Cu-based cast Al alloy according to any of claims 1 to 4, wherein said non-Cu-based cast Al alloy is used for vehicle wheels.

20 6. A method for heat treatment of a cast Al alloy comprising;



subjecting a work piece of the cast Al alloy to solution treatment, and then

subjecting the work piece to aging treatment, to improve mechanical properties of the work piece,

5 wherein at least said solution treatment is performed by rapidly raising the temperature to the solution treatment temperature within 30 minutes, and maintaining said solution treatment temperature within 3 hours to form the non-Cu-based cast Al alloy that has a tensile strength of 305 MPa  
10 or more, a 0.2% yield strength of 220 MPa or more, and an elongation of 10% or more.

7. A method for heat treatment of a cast Al alloy comprising;

15 subjecting a work piece of the cast Al alloy to solution treatment, and then

subjecting the work piece to aging treatment, to improve mechanical properties of the work piece,  
wherein at least said solution treatment is performed by allowing said work piece to be present in a fluidized bed  
20 to form the non-Cu-based cast Al alloy that has a tensile strength of 305 MPa or more, a 0.2% yield strength of 220 MPa or more, and an elongation of 10% or more.

8. The method of heat treatment according to claim 7,  
wherein said aging treatment is performed by allowing said  
25 work piece to be present in a fluidized bed.

9. The method of heat treatment according to claim 7 or 8, wherein said fluidized bed is formed by the direct blowing of hot air.

## ABSTRACT

A non-Cu-based cast Al alloy contains substantially no Cu, and has a tensile strength of 305 MPa or more, a 0.2% yield strength of 220 MPa or more, and an elongation of 10% or more. In the heat treatment of the cast Al alloy, the solution treatment is performed using a fluidized bed 18, and the solution treatment is performed by rapid heating up to the solution treatment temperature in 30 minutes, and maintaining the solution treatment temperature in 3 hours or less. Because this method for heat treatment performs solution treatment at an increased speed of heating-up time, with small deviation of temperature, and at a higher temperature, total time for heat treatment can be shortened drastically in comparison with the conventional method. A non-Cu-based cast Al alloy having well-balanced mechanical properties of tensile strength, yield strength, and elongation can be provided.

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FIG. 1

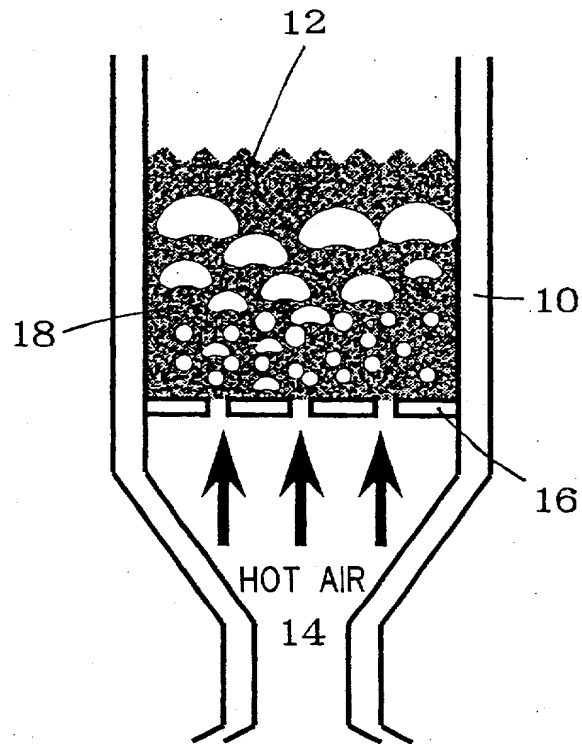
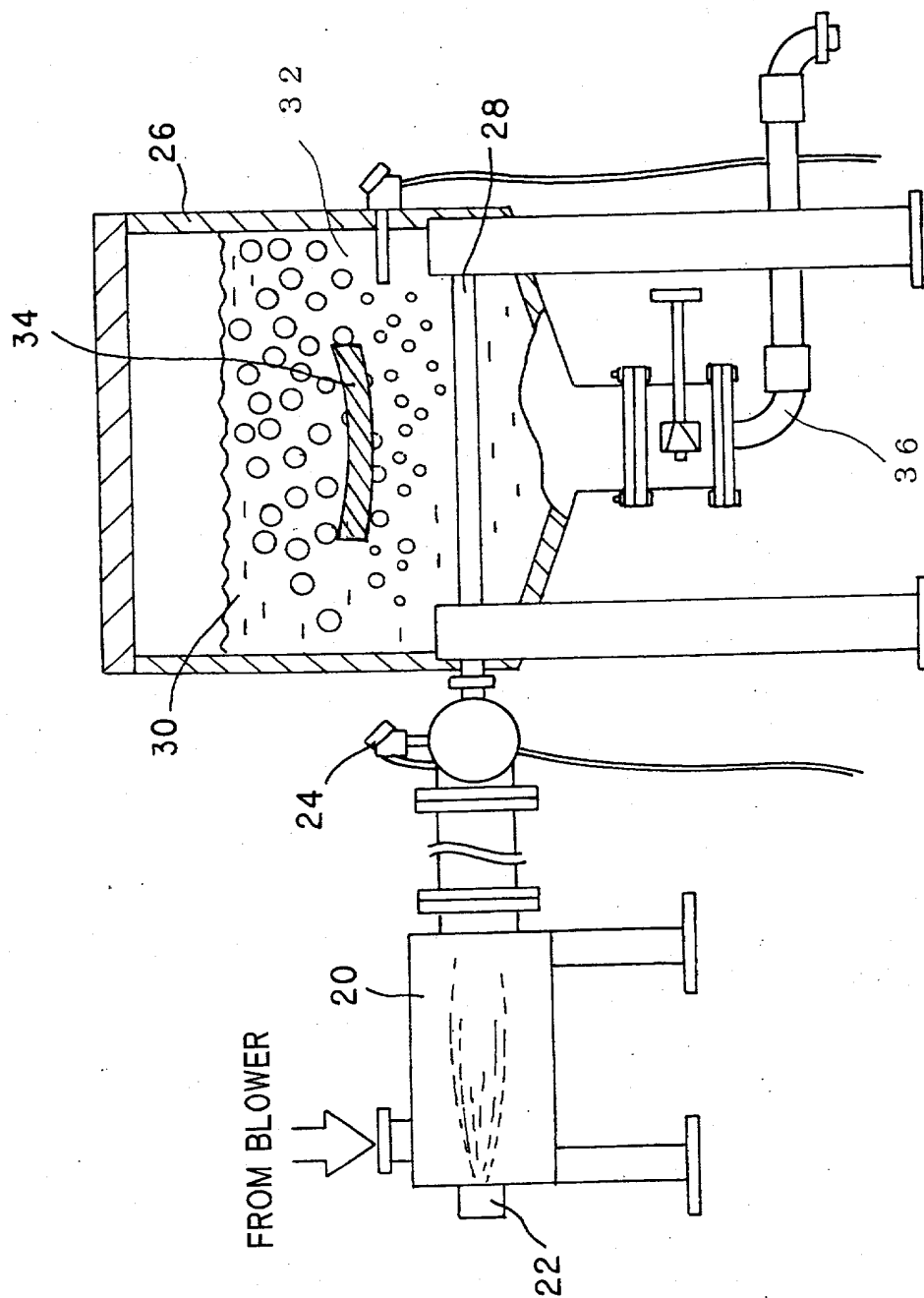


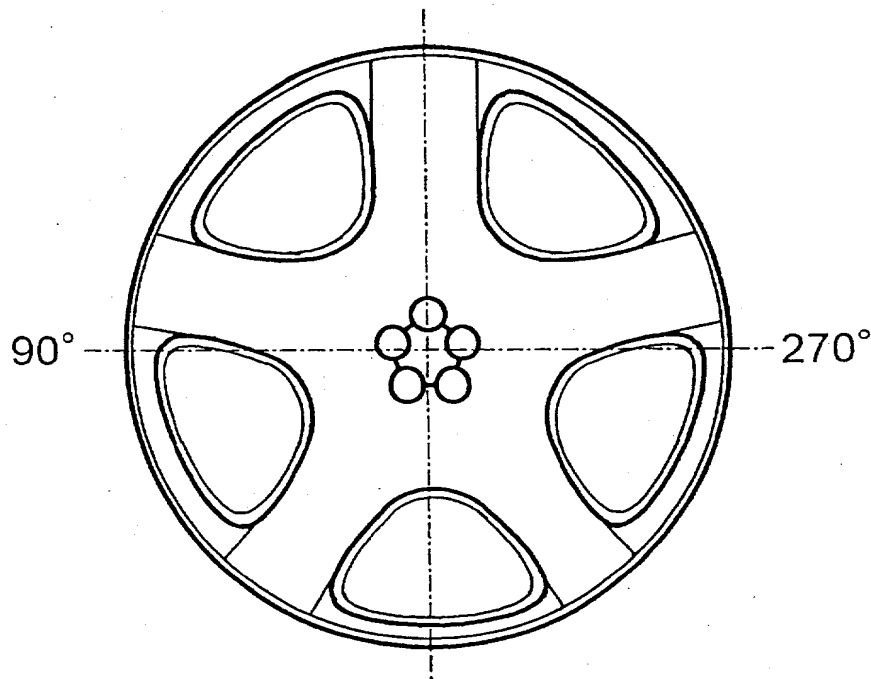
FIG. 2



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FIG. 3

COUNTER OPERATOR SIDE GATE



OPERATOR SIDE GATE

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FIG. 4

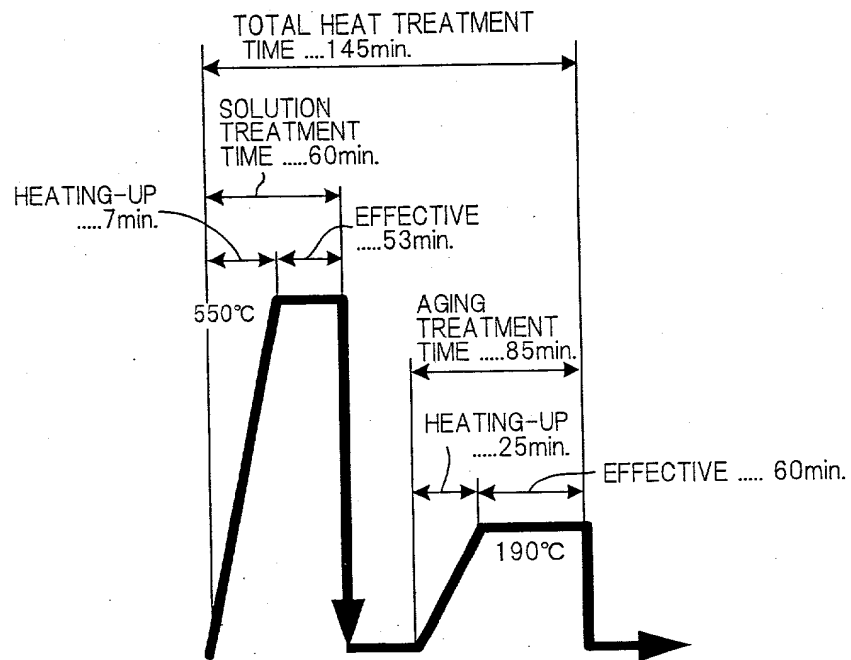


FIG. 5

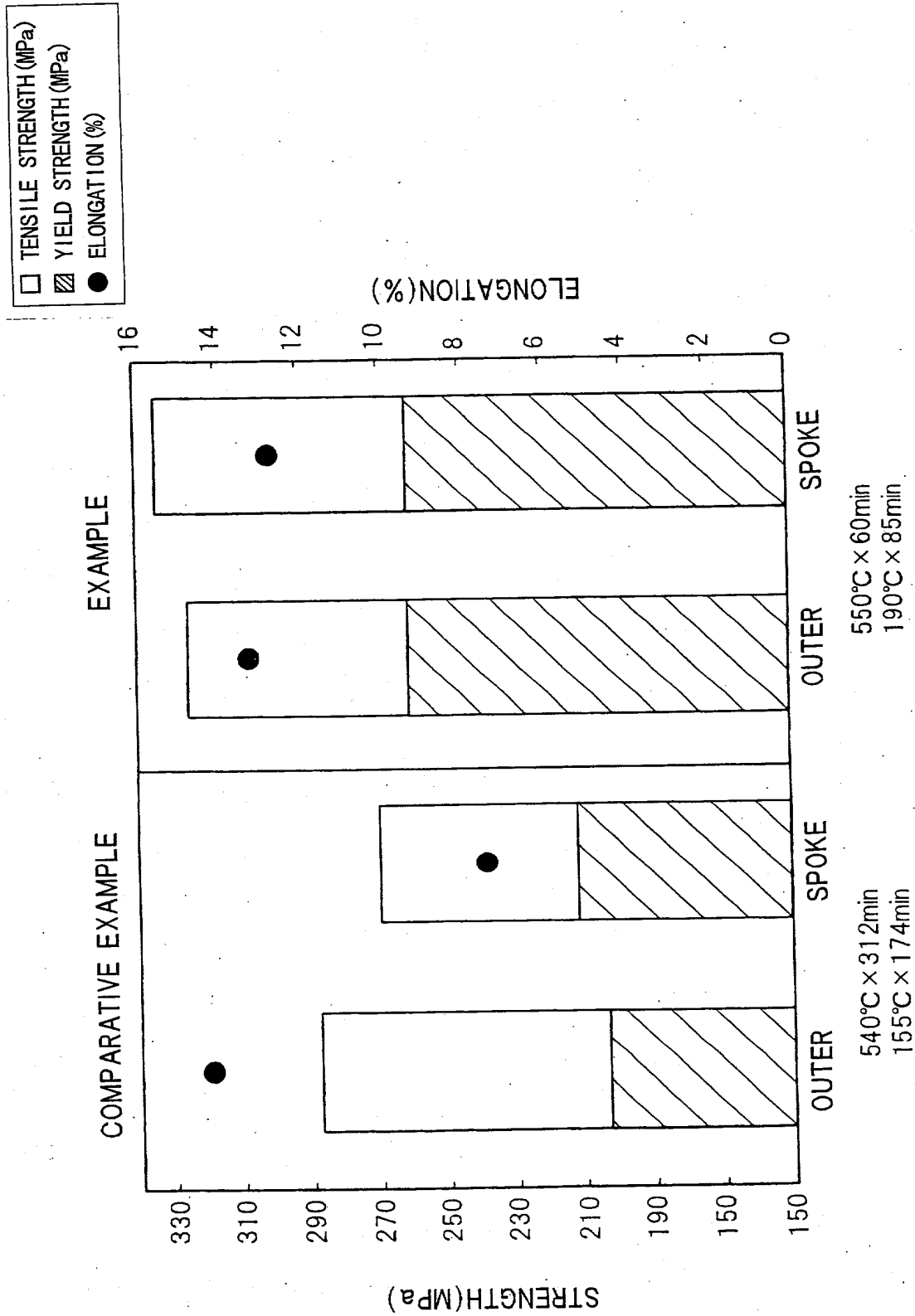




FIG. 6

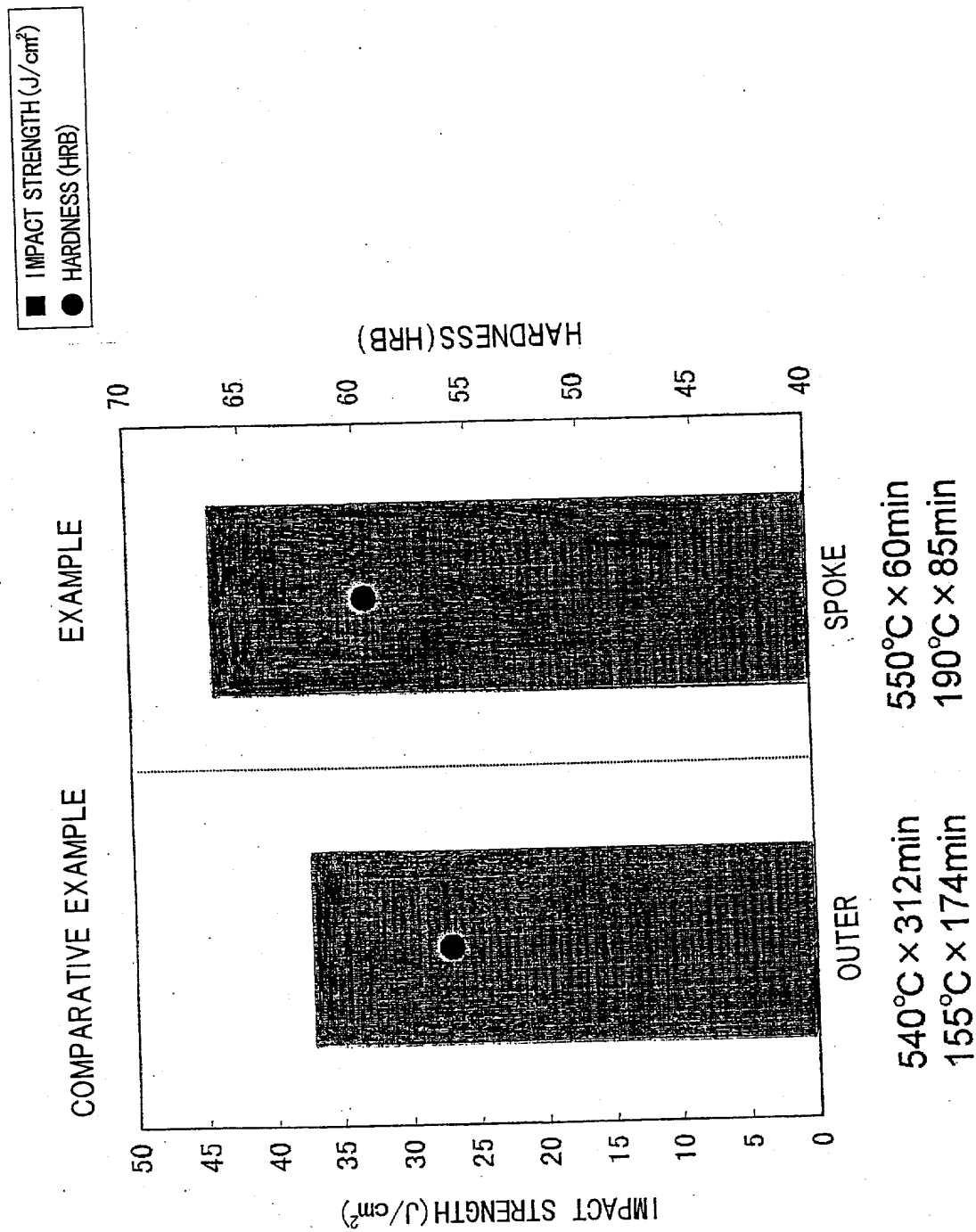
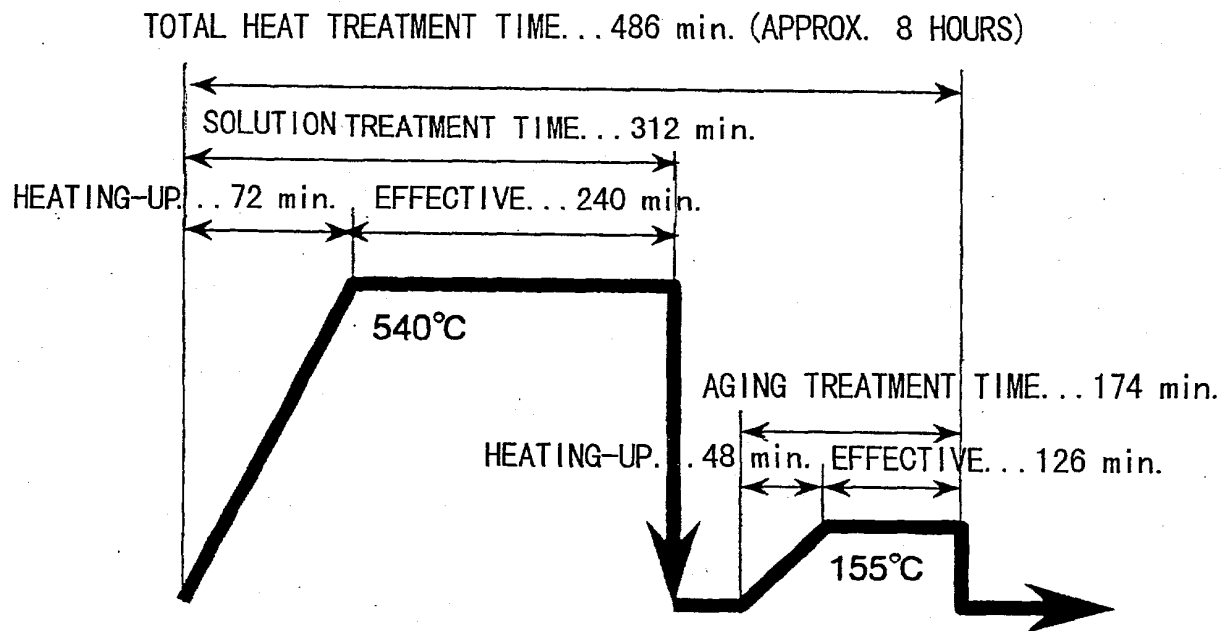


FIG. 7



Declaration and Power of Attorney  
Under Patent Cooperation Treaty  
35 USC §371(c)(4)

P-1672 PCT  
WA-056560 PCT  
US  
O I P E  
MAR 15 2002  
JCS  
PATENT & TRADEMARK OFFICE

As a below named inventor, I hereby declare that:

my residence, post office address and citizenship are as stated below next to my name; that

I verily believe that I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural names are named below) of the invention entitled: Non-Cu-Based Cast Al Alloy and Method for Heat Treatment Thereof

described and claimed in the international application number PCT/JP00/05600 filed August 22, 2000 and as amended on \_\_\_\_\_ (if any), the specification and claims of which I have reviewed and understand and for which I solicit a patent.

I acknowledge my duty to disclose information of which I am aware which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a), and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to my international application by me or my legal representatives or assigns, except as follows:

Japanese patent application No.11-246813 filed on August 31, 1999,  
Japanese patent application No.2000-056560 filed on March 1, 2000, and  
Japanese patent application No.2000-131414 filed on April 28, 2000.

The priority of the above applications (if any), filed within a year prior to my international application is hereby claimed under 35 USC 119. I hereby appoint the following as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the patent office:

Roger W. Parkhurst, Reg. No. 25,177; Charles A. Wendel, Reg. No. 24,453; Lawrence D. Eisen, Reg. No. 41,009.

ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO:  
PARKHURST & WENDEL, L.L.P., 1421 PRINCE STREET, SUITE 210, ALEXANDRIA, VIRGINIA 22314-2805, TELEPHONE (703) 739-0220.

I hereby declare that I have reviewed and understand the contents of this Declaration, and that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

3. Full Name of Sole or First Inventor Takayuki SAKAI  
Given Name Middle Initial Family Name  
\*4. Inventor's Signature Takayuki Sakai  
Date of Signature February 14th 2002  
Month Day Year  
6. Residence Kikugawa-cho Shizuoka-prefecture Japan JPX  
City State or Province Country  
7. Citizenship Japanese  
8. Post Office address c/o Asahi Tec Corporation,  
(Insert complete mailing address, including country) 547-1, Horinouchi, Kikugawa-cho, Ogasa-gun, Shizuoka-prefecture, 439-8651 Japan

\*IF THERE IS MORE THAN ONE INVENTOR USE PAGE 2 AND PLACE AN "X" HERE ☐.